Predicting Distribution and Properties of Buried Submarine Topography on Continental Shelves

Sergio Fagherazzi
Department of Geological Sciences and School of Computational Science
Florida State University
Dirac Science Library
Office 462 DSL
Tallahassee FL, 32306-4120
Phone: (850) 644-4274, Fax: (850) 644-0098 E-mail: sergio@csit.fsu.edu

Award Number: N00014-05-1-0071
http://www.gly.fsu.edu/~fagherazzi/

LONG-TERM GOALS

The long-term goal of the Geoclutter modeling project is to predict the distribution and properties of buried channels that may be responsible for geoclutter on continental margins of interest.

OBJECTIVES

The overall objectives of our project are

1) to determine the characteristics of channel features that can form when the present continental shelf is subject to sea-level variations and

2) to determine whether these features would be buried when sea-level returned to its present position and, if so, how deeply. During FY05, our objectives have been to complete the channel incision model DeLim and to test it on two selected locations. As related projects we have explored the possibility of incorporating in our modeling framework tidal channels and inlets, which are ubiquitous in the geological record.

APPROACH

Our approach is to develop numerical simulation models of landscape evolution to investigate the development of topography on the shelf during sea-level low stands and the burial of that topography during high sea-level conditions. Our model is based on Alan Howard's drainage basin evolution model, DELIM. Alan Howard and Sergio Fagherazzi have adapted, tested, and applied the landscape evolution model to coastal plain settings and exposed continental shelves. Sergio Fagherazzi has developed and implemented coastal modules and Patricia Wiberg has developed shelf sediment transport modules for the land/sea-scape evolution model.

We have completed and parameterized the nearshore module. Model results show that sediment availability is critical for channel burial and preservation in the geological record whereas the intensity of nearshore processes controls the erasure of fluvial incisions.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2005**	2. REPORT TYPE	3. DATES COVERED **00-00-2005 to 00-00-2005**

4. TITLE AND SUBTITLE **Predicting Distribution and Properties of Buried Submarine Topography on Continental Shelves**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Florida Atlantic University,Department of Ocean Engineering,Boca Raton,Fl,33431**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

The model was then applied to two shelf sites: the Western Florida shelf and the Adriatic Sea in the Mediterranean. the Western Florida shelf was chosen because of the availability of a geologic database that includes over 3000 surface sediment samples, more than 400 sediment cores, high resolution bathymetry, and over 3000 km of sub-bottom seismic lines. We can thus directly compare our model results to the characteristics of the shelf and the geometry of the buried paleochannels.

The Adriatic Sea was chosen because of ongoing research projects under the EuroStrataform program. The availability of extensive datasets facilitates the model application and the results interpretation. Our model simulations provide a long-term description of coupled fluvial-shelf processes that is complementary to other modeling efforts in the same area (Syvitski and Kettner, 2004; Niedoroda et al. 2005; Sherwood et al. 2005).

RESULTS

The Detachment Limited Model has been applied to the Western part of the Florida shelf to simulate the development of rivers and related incisions and channel preservation during sea-level cycles. The sediments of the northeastern Gulf of Mexico shelf are derived from the major alluvial rivers that drain watersheds extending well into Georgia and Alabama (Figure 1). Sediments are redistributed primarily by longshore transport processes acting in the nearshore zone, although there is much slow but continuous reworking of the sands on the continental shelf. The river systems that provide sediments to the coast occupy upland watersheds that have changed little during the past few million years. Thus the primary upland sediment sources have remained the same during the glacial era. Sub-bottom seismic profiling data indicate that the river systems of north Florida extended well beyond their present mouths during sea-level lowstands, creating extensive networks of fluvial features on what is now the inner and mid-shelf. Many of the smaller rivers which presently terminate at the modern coast were tributaries of the larger rivers during lowstands (see Figure 2). Many of the sub-bottom records also reveal that the paleo-rivers were generally larger than at present (implying wetter conditions), and that the drainage was in many places dominated by karst processes (Donoghue, 1993; Faught and Donoghue 1997; Chen 1999; Schnable and Goodell 1968). Given the fact that this coastal region has been predominantly influenced by river deposition and erosion throughout the Quaternary, with little influence of tectonic and marine processes, this study area presents a propitious opportunity to effectively compare our models with field data.

Modeling results show that the main streams dissecting the shelf during lowstand are preserved as buried paleochannels. The orientation of the channels east of Apalachicola bay is well reproduced by the synthetic channels (compare figure 1A to 1D), as well as their geometry. Along the coastline west of Apalachicola bay the main rivers departing from the mainland are conserved in the stratigraphic record, but many buried paleochannels are not linked to existing streams. Ongoing research is showing that these incisions have three distinct origins: some are local streams that form in the shelf during low sea level conditions and are well represented by the network of small channels simulated by our model (see figure D); some formed by avulsion of the major rivers triggered by sea level oscillations, the remaining have a tidal origin and are either paleoinlets or intertidal channels preserved in the geological record. More research in needed to characterize the location and properties of the tidal paleochannels.

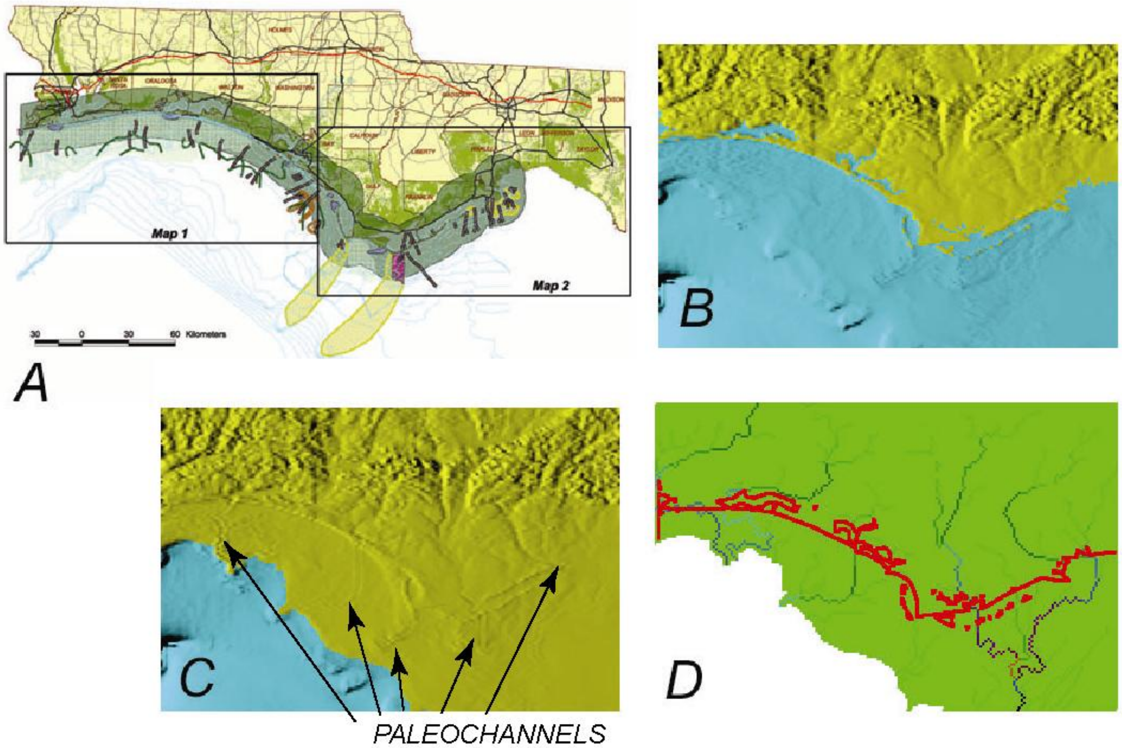

Figure 1: Application of the DeLiM model to the Northwest Florida Shelf (A) location of buried paleochannels from seismic data (courtesy DEP Florida) (B) topography used in the model simulations (C) topography after 20000 years and a constant sea level decrease of 3 mm/yr (D) main streams present on the shelf during low stand conditions

The model was subsequently applied to the Adriatic shelf (Italy) to track the evolution of the Po River (the major river flowing in the Adriatic Sea) and its tributaries during sea-level cycles. Numerical simulations show that the Po River during sea level low-stands dissects the entire Adriatic shelf, flowing into the Mediterranean Sea 500 km away from the actual delta. The peculiar characteristics of the Adriatic Sea dictate the evolution and degree of incision of fluvial channels in the shelf. Its narrow epicontinental basin prevents the distribution of fluvial sediments over large areas. Moreover the Apennine Rivers flowing into the Adriatic Sea along the west coast of Italy are easily captured by the Po River during sea level low stands. The capture of these rivers is critical for channel incision and sediment deposition in the shelf. The complex morphology of the shelf influences the redistribution of sediments during sea-level oscillations. Thick deposits formed by prograding deltas are located at the high stand locations of river mouths, whereas shallow paleolakes formed in the lowest areas of the shelf are filled during the evolution.

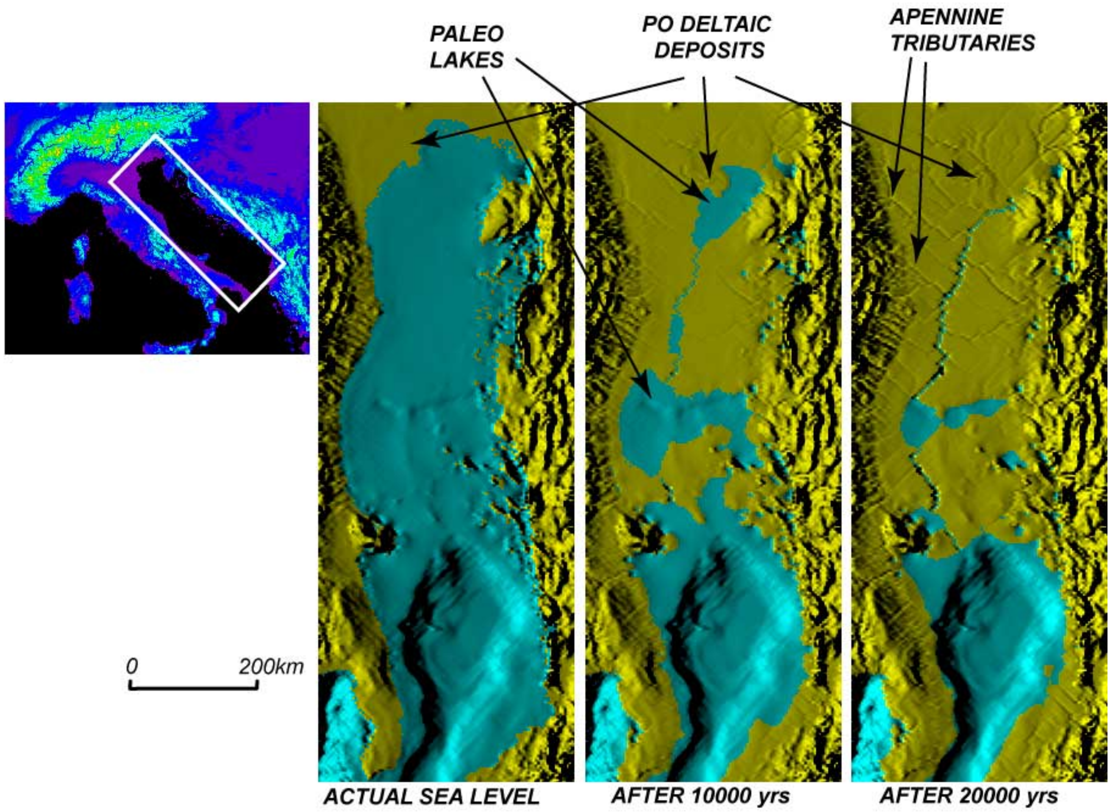

Figure 2: Application of the DeLiM model to the Adriatic Sea (A) location of the Adriatic Sea within Europe (B) actual topography of the Adriatic Sea (C) topography after 10000 years (D) topography after 20000. The sea level was decreased at the constant rate of 3 mm/yr

IMPACT/APPLICATIONS

The application of the model to the Adriatic Sea is of interest to EuroStrataform and other colleagues. Our modeling exercise integrates the terrestrial and nearshore processes that are responsible for channel incision and related burial within the same framework, and complements already developed high resolution models. The model, at the end of the testing phase, will provide an estimation of the distribution, frequency, and geometry of paleochannels in continental shelves.

TRANSITIONS

The application of the model to the Western Florida Shelf will be applied for the development of outer continental shelf (OCS) oil and natural gas resources. The model results are of interest to the Petroleum Research Fund.

RELATED PROJECTS

Sedimentological and stratigraphic data show that several buried paleochannels are of tidal origin, being either ancient tidal inlets or intertidal channels. Partly supported by this grant, we have developed a model for the formation of tidal channels in intertidal areas (Fagherazzi and Sun 2004, D'Alpaos et al.

2005, D'Alpaos et al. 2005) and we are exploring the long-term morphological evolution of the channels in response to physical forcing. We are also planning to expand the modeling framework to tidal inlets and determine under what conditions these incisions are buried and maintained in the geological record. To this end we are quantifying the modality of sediment redistribution in intertidal areas (Carniello et al., 2005), and extract long-term trends that will shed light on the burial mechanisms that preserve the channels.

REFERENCES

Chen, Z.Q., Late Quaternary history of the northeastern Gulf of Mexico coast, northwest Florida. unpubl. PhD dissertation, Florida State University, 341 p., 1999

Donoghue, J.F., 1993. Late Wisconsinan and Holocene depositional history, northeastern Gulf of Mexico. Marine Geology, 112, 185-205.

Faught, M.K., and Donoghue, J.F., 1997, Marine inundated archaeological sites and paleofluvial systems: Examples from a karst-controlled continental shelf setting in Apalachee Bay, Northeastern Gulf of Mexico: Geoarchaeology, v. 12, p. 417-458.

Schnable, J.E., and Goodell, H.G., Pleistocene-Recent Stratigraphy, Evolution, and Development of the Apalachicola Coast, Florida. Geological Society of America Special Paper No. 112. Boulder, CO: Geological Society of America, 72 p.,1968.

Syvitski, J.P.M., and Kettner, A.J., 2004. On the Flux of Water and Sediment into the Northern Adriatic. Continental Shelf Research. Submitted 2005

Sherwood, C.R., S. Carniel, L. Cavaleri, J. Chiggiato, H. Das, J.D. Doyle, C.K. Harris, A.W. Neidoroda, J. Pullen, C.W. Reed, N. Russo, R.P. Signell, P. Traykovski, J.C. Warner Sediment dynamics in the Adriatic Sea investigated with coupled models. Submitted to Oceanography, 2005.

PUBLICATIONS
(* denotes student coauthor)

Fagherazzi S., Models of Deltaic and Continental Shelf Landform Evolution, *Annual Review of Earth and Planetary Sciences* (in preparation)

Fagherazzi S., Howard A.D., Wiberg P.L., Coupling fluvial incision, delta deposition, and coastal processes on continental shelves during sea-level cycles (in preparation)

Fagherazzi S., Carniello L.*, D'Alpaos L., Defina A., Critical bifurcation of coastal landforms in tidal flats and salt marshes (submitted)

D'Alpaos A.*, Lanzoni S., Mudd S.M., Fagherazzi S., Modeling the influence of hydroperiod and vegetation on the cross-sectional formation of tidal channels *Estuarine, Coastal and Shelf Science* (in press)

Niedoroda A.W., Reed C.W., Das H., Fagherazzi S., Donoghue J.F., and Cattaneo A., Analyses of a large-scale depositional clinoform along the Italian Adriatic coast, *Marine Geology*, (in press)

Carniello L.*, Defina A., Fagherazzi S., D'Alpaos L., A combined Wind Wave-Tidal Model for the Venice Lagoon, Italy *J. Geophys Res. Earth Surface* (in press)

D'Alpaos A.*, Lanzoni S., Marani M., Fagherazzi S., and Rinaldo A., Tidal network ontogeny: Channel initiation and early development, *J. Geophys Res. Earth Surface*, Vol. 110, No. F2, F02001 10.1029/2004JF000182, 2005.

Fagherazzi S., Howard A.D., Wiberg P.L., Coupling fluvial incision, delta deposition, and coastal processes on continental shelves during sea-level cycles (invited), American Geophysical Union, Transactions, Fall Meeting, 2005

Fagherazzi S., Coastal and near-shore processes in relation to protection and management of coastal lands and wetlands, key note speaker (invited), National Cross-Disciplinary Workshop in Engineering and Geoscience, *Process-Driven Risk Assessment and Sustainable Mitigation Strategies* Vanderbilt University, Nashville, Tennessee September 11-14, 2005

Fagherazzi S., Tidal flow field in a small basin, SCS Workshop: Applications of Optimal Control and EnKF to Flow Simulation and Modeling, Florida State University, February 23-24, 2005

Carniello L., D'Alpaos L., Defina A., Fagherazzi S., Tidal flat-salt marshes transition in shallow tidal lagoons, *European lagoons and their watersheds: function and biodiversity* Klaipeda, Lithuania, October 4-9, 2005

D'Alpaos A., Fagherazzi S., Lanzoni S., On the cross-sectional evolution of tidal creeks *4th IAHR Symposium on River, Coastal and Estuarine Morphodynamics*, Urbana, Illinois, USA October 4 - 7, 2005